CSIRO PUBLISHING
Australian Health Review
http://dx.doi.org/10.1071/AH15225

Identifying areas of need relative to liver disease: geographic clustering within a health service district

Nathan El-Atem[1,2,3] B Dental Science, MPhil Candidate
Katharine M. Irvine[4] PhD, BSc (Hons), LLB, Research Fellow
Patricia C. Valery[5] MD, MPhil, PhD, Associate Professor
Kyle Wojcik[4] BSc, MD Student
Leigh Horsfall[4,6] RN, Research Co-ordinator
Tracey Johnson[7] BComm, Grad Dip Mgt, M Pub Mgt, Grad Dip Th, Practice Manager
Monika Janda[1] PhD, Senior Research Fellow
Steven M. McPhail[1,2,3,*] BPhysiotherapy, PhD, Associate Professor
Elizabeth E. Powell[4,6,8,*] MBBS, FRACP, PhD, Professor

[1]Institute of Health and Biomedical Innovation, Queensland University of Technology, 60 Musk Avenue, Kelvin Grove, Qld 4059, Australia. Email: nathan.elatem@uqconnect.edu.au; m.janda@qut.edu.au; steven.mcphail@qut.edu.au
[2]School of Public Health and Social Work, Queensland University of Technology, Victoria Park Road, Kelvin Grove, Qld 4059, Australia.
[3]Centre for Functioning and Health Research, Metro South Health, PO Box 6053, Buranda, Qld 4102, Australia.
[4]Centre for Liver Disease Research, The University of Queensland, Translational Research Institute, 37 Kent Street, Woolloongabba, Qld 4102, Australia. Email: katharine.irvine@uq.edu.au; kyle.wojcik@uq.net.au
[5]QIMR Berghofer Medical Research Institute. 300 Herston Road, Herston, Qld 4006, Australia. Email: Patricia.Valery@qimrberghofer.edu.au
[6]Department of Gastroenterology and Hepatology, Princess Alexandra Hospital, Ipswich Road, Woolloongabba, Qld 4102, Australia. Email: Leigh.Horsfall@health.qld.gov.au
[7]Inala Primary Care, 64 Wirraway Parade, Inala, Qld 4077, Australia. Email: tjohnson@inalaprimarycare.com.au
[8]Corresponding author. Email: e.powell@uq.edu.au

Abstract

Background. Many people with chronic liver disease (CLD) are not detected until they present to hospital with advanced disease, when opportunities for intervention are reduced and morbidity is high. In order to build capacity and liver expertise in the community, it is important to focus liver healthcare resources in high-prevalence disease areas and specific populations with an identified need. The aim of the present study was to examine the geographic location of people seen in a tertiary hospital hepatology clinic, as well as ethnic and sociodemographic characteristics of these geographic areas.

Methods. The geographic locations of hepatology out-patients were identified via the out-patient scheduling database and grouped into statistical area (SA) regions for demographic analysis using data compiled by the Australian Bureau of Statistics.

Results. During the 3-month study period, 943 individuals from 71 SA Level 3 regions attended clinic. Nine SA Level 3 regions accounted for 55% of the entire patient cohort. Geographic clustering was seen especially for people living with chronic hepatitis B virus. There was a wide spectrum of socioeconomic advantage and disadvantage in areas with high liver disease prevalence.

Conclusions. The geographic area from which people living with CLD travel to access liver health care is extensive. However, the greatest demand for tertiary liver disease speciality care is clustered within specific geographic areas. Outreach programs targeted to these areas may enhance liver disease-specific health service resourcing.

*These authors contributed equally to this work.

What is known about the topic? The demand for tertiary hospital clinical services in CLD is rising. However, there is limited knowledge about the geographic areas from which people living with CLD travel to access liver services, or the ethnic, socioeconomic and education characteristics of these areas.
What does this paper add? The present study demonstrates that a substantial proportion of people living with CLD and accessing tertiary hospital liver services are clustered within specific geographic areas. The most striking geographic clustering was seen for people living with chronic hepatitis B, in regions with a relatively high proportion of people born in Vietnam and China. In addition to ethnicity, the data show an apparent ecological association between liver disease and both socioeconomic and educational and/or occupational disadvantage.
What are the implications for practitioners? Identifying where demand for clinical services arises is an important step for service planning and preparing for potential outreach programs to optimise community-based care. It is likely that outreach programs to engage and enhance primary care services in geographic areas from which the greatest demand for tertiary liver disease speciality care arises would yield greater relative return on investment than non-targeted outreach programs.

Received 11 December 2015, accepted 20 June 2016, published online 11 August 2016

Introduction

The global burden of liver disease is rising, due, in part, to an increasing prevalence of alcoholic liver disease (ALD) and non-alcoholic fatty liver disease (NAFLD), as well as untreated viral hepatitis.[1–3] A recent comprehensive review of liver disease in the UK noted an imbalance between service provision and clinical need, and identified that knowledge and awareness of liver disease in primary care was low, with a lack of training in the diagnosis and management of early liver disease.[4] It was recognised that many people with cirrhosis were not detected until they presented to hospital with advanced liver disease, when opportunities for intervention are reduced and morbidity is high.[4] Similarly, in Australia, management of liver disease presents challenges at many levels, from organisational and geographical impediments to effective management in the primary care setting. One-quarter of new cases seen in specialist hepatology clinics at the Princess Alexandra Hospital, a major tertiary referral centre in Brisbane, Queensland, presented with advanced liver disease[5] and more than one-third of referred patients with chronic hepatitis C virus (HCV) infection had comorbidities such as heavy alcohol consumption, obesity and type 2 diabetes, which increase the risk of progressive liver disease and related complications.[6] The sparse liver clinics and hepatitis treatment centres in Queensland[7] and the recently documented long wait times for out-patient hepatology services[6] may be some of the contributing factors to patients presenting with advanced disease.

Although liver disease shares some common lifestyle risk factors, it is not generally considered as one of the chronic lifestyle-related diseases that are managed in primary care, such as cardiovascular disorders, diabetes, chronic lung or renal disease. However, it is clear that increased involvement of primary care clinicians in the detection and management of liver disease is necessary in order to identify people at risk of progressive disease and enable earlier intervention and management of comorbidities. Effective management in the community may be hampered by a lack of experience with liver disease, with low numbers of patients identified by individual general practitioners (GPs).[6] With a view to building capacity and liver expertise in the community, it may be logical to focus training or mentoring of GPs in high-prevalence disease areas and specific populations with an identified need.

In order to better understand the geographic areas of need relative to liver disease in the Metro South Hospital and Health Services (HHS) district, we undertook a retrospective audit of people seen in the tertiary referral hepatology clinics over a 3-month period. The main aim of the present study was to describe the geographic location (place of residence) of people seen in the liver clinics. The secondary aim was to examine associations between patient demand for tertiary hepatology services and the ethnic and sociodemographic characteristics of the geographic areas with clustering of people living with chronic liver disease (CLD), as well as the characteristics of the individuals clustered within these areas.

Methods

Patients and clinical data

The study included consecutive patients booked in hepatology out-patient clinics at the Princess Alexandra Hospital (Brisbane, Qld, Australia) over a 3-month period in 2013. This facility has a dedicated gastroenterology and hepatology department and is the primary referral centre for public patients with liver disease within the Metro South HHS district, which spans 3856 km^2 and serves an estimated population of 1 million. The study protocol was approved by the Metro South HHS and Queensland University of Technology Human Research Ethics Committees, who granted a waiver of individual consent because the study used routinely collected clinical and hospital booking systems data that were anonymised and involved no risk to patients' rights or welfare.

Demographic information collected for each patient included age, gender, postcode, use of an interpreter and type of appointment (new or review). Data for each appointment were retrieved from the out-patient scheduling database, corresponding clinic letters and clinical databases, with aetiology and disease severity classified by a hepatologist (EEP). Diagnosis of liver disease was based on standard biochemical and serological assays. Liver disease severity was broadly classified as 'no advanced disease' or 'advanced disease' (advanced fibrosis, as determined by transient elastography, liver biopsy if available or liver imaging

consistent with cirrhosis and/or portal hypertension; decompensated liver disease, as determined by the presence of ascites, hepatic encephalopathy or variceal bleeding; or hepatocellular carcinoma (HCC), diagnosed by imaging or histology).

Geographical areas

The Australian Statistical Geography Standard (ASGS, http://www.abs.gov.au/websitedbs/D3310114.nsf/home/Australian+Statistical+Geography+Standard+(ASGS), accessed 14 June 2016) provides a regional break-up of Australia with spatial units ranging from Statistical Area Level 1 (SA1; the smallest) to SA4, through to state/territory, and Australia. In the present study, SA3 data were used for population-level descriptive statistics and heat mapping. Data describing geographical regions were obtained from the Australian Bureau of Statistics (ABS) Socio-Economic Indexes for Areas (SEIFA, 2011, http://www.abs.gov.au/ausstats/abs@.nsf/DetailsPage/2033.0.55.0012011?OpenDocument, accessed 2015), including the Index of Relative Socio economic Advantage and Disadvantage (IRSAD and the Index of Education and Occupation (IEO. The IRSAD describes the average socioeconomic characteristics of people and households living within an area, with a low score (or decile) indicating relatively greater disadvantage. The IEO represents qualification and occupation skill levels, as classified by the Australian and New Zealand Standard Classification of Occupations, with low IEO scores indicating relatively lower education and occupation status of people in the area. For the purpose of describing SA3s represented in the present study, we calculated the proportion of SA1s within the three most disadvantaged IRSAD and IEO deciles (1–3) for each SA3. IRSAD and IEO scores were used for the multivariable analysis and multilevel modelling.

Multivariable analyses and multilevel modelling

Generalised linear modelling was used to examine SA2 aggregate population characteristics associated with higher counts of patients accessing tertiary hepatology services, whereas generalised linear mixed (multilevel) modelling was used to investigate attributes of hepatology patients clustered within geographical areas relative to a representative sample from the same region. These explanatory models were prepared for total demand, as well as demand arising from patients presenting with NAFLD, HCV, hepatitis B virus (HBV) and ALD, using Stata 13 MP (StataCorp)[8] and R (https://www.r-project.org/).[9]

For the model examining aggregate SA2 characteristics, the dependent variable was the total number of hepatology patients, or patients with each aetiology of interest, originating from each SA2 region, including 101 SA2 regions in the Metro South HHS and one SA2 region from the neighbouring West Moreton HHS from which 19 patients originated. Aggregate population characteristics of each SA2 region, including median age, number of males, number of Aboriginal and Torres Strait Islander (ATSI) people, number of people born in Australia and other regions (Oceania, North-west Europe, Southern and Eastern Europe, North Africa and the Middle East, South-east Asia, North-east Asia, Southern and Central Asia, Americas, Sub-Saharan Africa), IRSAD or IEO, and number of people who do not speak English as their primary language at home, were extracted from the 2011 ABS Australian Population and Housing Census community profiles.[10,11] Least absolute shrinkage and selection operator (LASSO) regression[12] was used for variable selection, followed by generalised linear modelling to determine which SA2 characteristics were associated with total or aetiology-specific demand for hepatology services. Akaike's

Table 1. Demographic and clinical data for 943 individuals attending the hepatology clinic over a 3-month period

Data are given as the mean ± s.d. or as *n* (%), as appropriate. NAFLD, non-alcoholic fatty liver disease; ALD, alcohol-related liver disease; SA3, Statistical Area Level 3

Age (years)	52 ± 13
Gender	
Male	585 (62%)
Female	358 (38%)
Liver disease aetiology	
Hepatitis C	326 (35%)
Hepatitis B	283 (30%)
NAFLD	115 (12%)
ALD	69 (7%)
Other[A]	150 (16%)
Liver disease severity	
No advanced disease	564 (60%)
Advanced disease[B]	379 (40%)
Overseas-born residents country of origin[C]	
Total	463 (100%)
% Requiring interpreter	25.3
New Zealand	72 (16%)
% Requiring interpreter	0
Vietnam	71 (15%)
% Requiring interpreter	66.7
England	32 (7%)
% Requiring interpreter	0
China	24 (5%)
% Requiring interpreter	60.0
Philippines	23 (5%)
% Requiring interpreter	0
Taiwan	19 (4%)
% Requiring interpreter	61.3
Most common SA3 regions represented[D]	
A[E]	82 (9%)
B	74 (8%)
C	60 (6%)
D[F]	56 (6%)
E	55 (5%)
F	48 (5%)
G	45 (5%)
H	44 (5%)
I	44 (5%)

[A]'Other' includes drug-induced liver injury, liver lesions, abnormal iron studies, immune-mediated disease, cryptogenic disease, thrombotic disorders and biliary disorders.

[B]'Advanced disease' refers to advanced fibrosis, decompensated liver disease or hepatocellular carcinoma.

[C]Percentages in parentheses refer to the percentage of overseas-born residents.

[D]There were 67 SA3 regions represented of 80 SA3 regions in Queensland, and four from other states.

[E]SA3 region identification is shown in Fig. 1 and can be obtained from the corresponding author.

[F]SA3 region located within West Moreton Hospital and Health Services district.

information criterion (AIC) was used to find the most appropriate parameterisation for optimal model fit with penalty for complexity (to avoid overfitting the model).[13,14] Robust standard errors (Huber–White sandwich variance estimator approach[15,16]) were used and a Poisson family and log link option produced the most parsimonious models.

Multilevel modelling investigating the characteristics of individuals clustered within geographical regions required information from both clinic attendees and a matched sample of individuals in order to identify attributes of clinic attendees that may (or may not) have differed from a representative sample from the same regions. The personal attributes of a representative sample, matched to the clinic sample on age (within 5 years), gender and geographical area (based on ASGS SA4 regions, to preserve individuals' identity), were extracted from an ABS confidentialised unit record file from the 2011 Australian Population and Housing Census.[17] Potential explanatory variables for inclusion in this analysis were region of birth, identification as ATSI, English proficiency ('not having English proficiency' was defined as requiring a language interpreter

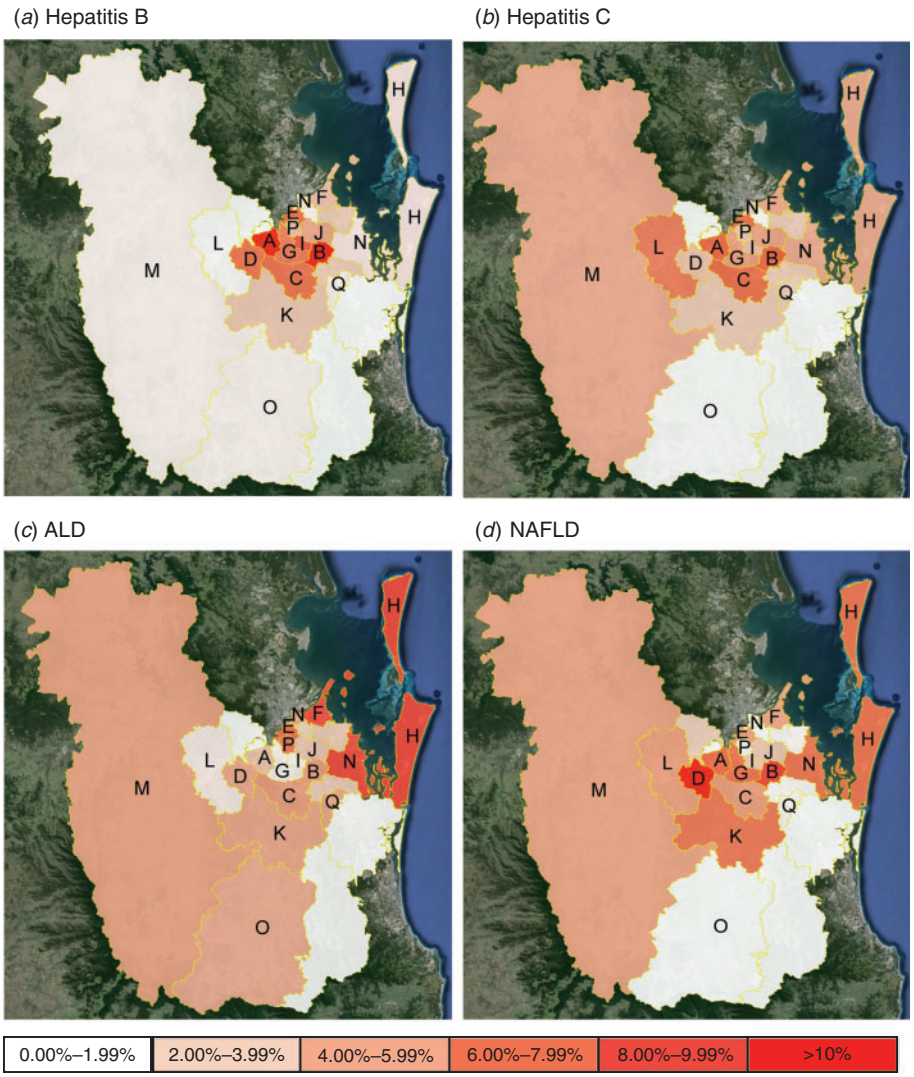

Fig. 1. Geographical source (Statistical Area Level 3 regions A–X) of liver clinic outpatients with the four most common causes of liver disease, namely hepatitis B (*a*), hepatitis C (*b*), alcohol-related liver disease (*c*) and non-alcoholic fatty liver disease (*d*), as a proportion of total liver clinic out-patient numbers with the disease (indicated by colour scale), mapped to the Metro South Hospital and Health Service district and surrounding region. Map data were obtained from Google, Scripps Institute of Oceanography (SIO), National Oceanic and Atmospheric Administration (NOAA), US Navy, US National Geospatial-Intelligence Agency (NGA), General Bathymetric Chart of the Oceans (GEBCO), Image Landsat, 2015. Google Earth v7.1.5.1557. 2015. Metro-South Region, Queensland, Australia 27°50′45.69″S, 152°52′17.71″E, elevation 0M. http://www.google.com/earth/index.html, viewed 14 June 2016.

during clinic or self-reporting low levels of English proficiency during the census) and the matching variables (age and gender). Within the region of birth variable, the reference for the model coefficient was 'Australian born and not ATSI'. The (binary) dependent variable for these multilevel analyses was whether the individual was a hepatology patient. Generalised linear mixed (multilevel) modelling was performed to examine factors associated with presenting for any reason, as well as for presenting with HCV, HBV, NAFLD or ALD. AIC was used as an indicator of model fit with penalty for complexity to guide model parametrisation.[13,14] The most parsimonious multilevel models were produced using two-level random intercept models (individuals clustered in their geographical areas) using the Bernoulli family and logit link option for the total demand model as well as for NAFLD, HCV and HBV. The correlation between individuals within geographical clusters during the multilevel modelling was estimated using intraclass correlation coefficients (ICC). The ALD two-level models did not provide a superior fit compared with a one-level model, and therefore the final models presented for ALD are single level (no random effect equation for geographical area) using the Bernoulli family and logit link option. Effect estimates from these models were expressed as odds ratios (ORs) for ease of interpretation, with robust standard errors (using the Huber–White sandwich variance estimator approach).[15,16] Because of the expected very high correlation between IRSAD and IEO indices (rho 0.90), IRSAD was included in the *a priori* primary models. However, sensitivity analyses were prepared by repeating the models using IEO instead of IRSAD to examine any potential effect on the model.

Results

Clinical and demographic characteristics of the liver out-patient clinic cohort

During the 3-month study period, 943 individuals attended a hepatology out-patient appointment. The four most common liver diseases (HCV, HBV, NAFLD and ALD) accounted for 84% of individuals seen in clinic. Forty per cent of the cohort had advanced liver disease. Overseas-born residents accounted for 49% of the clinic sample, with 69 countries represented, most commonly New Zealand (16%), Vietnam (15%), England (7%) China (5%) and Philippines (5%). A language interpreter was required by 11.3% of the total cohort and 25.3% of overseas-born patients (Table 1).

Geographic location of the liver out-patient clinic cohort reveals disease 'hotspots'

In order to better understand the areas of need for hepatology services, we examined the distribution of referrals from geographic subregions representing clusters of related suburbs within major urban areas, or regional towns, with populations between 30 000 and 130 000 people (SA3 regions). In all, 71 SA3 regions, of 80 SA3 regions in Queensland, were represented in the clinic sample, with 84% of individuals living in 20 SA3 regions. Eight of the nine SA3 regions accounting for 55% of the patient cohort were located within the Metro South HHS district, and the other was located within the neighbouring West Moreton HHS district.

Table 2. Characteristics of the Statistical Area Level 3 (SA3) regions (population, age, percentage of people born in Australia, disadvantage and education) from which the greatest demand for liver services arose

SA3 region[A]	% People with CLD				Population	Median age (years)	% People born in Australia[B]	% 'Disadvantaged' SA1s within SA3 region[C]	% 'Lower education' SA1s within SA3 region[C]
	HBV	HCV	ALD	NAFLD					
A	13.43	7.1	2.9	6.96	63 573	33	58.2	44.2	41.5
B	12.37	7.41	2.9	8.7	75 355	33	62.3	51.1	51.9
I	8.48	3.09	1.45	2.61	46 067	33	46.7	6.5	1.9
C	6.71	7.72	4.35	4.35	72 712	31	68.7	52.4	84.7
E	6.71	7.1	7.25	4.35	65 186	33	68.2	4.3	0
G	6.71	4.01	0	7.83	53 641	33	54.3	21.1	21.7
D[D]	6.01	3.7	5.8	11.3	66 360	29	66.1	47.2	58.7
J	4.59	4.94	2.9	2.61	65 662	35	61.4	8.1	2.7
F	3.53	4.63	8.7	4.35	65 027	37	73.2	12.1	15.3
P	2.83	2.78	7.25	0.87	36 517	35	65.3	8.1	2.3
K	2.12	2.78	4.35	6.96	37 343	35	77.9	3.3	65.9
H	1.77	4.01	8.7	6.96	76 459	41	71.7	20.1	22.3
L[D]	1.77	6.48	1.45	4.35	94 911	34	81.9	51.9	56.8
Q	1.06	3.7	5.8	0.87	37 758	34	69.4	56.3	71.6
M[D]	1.06	4.01	4.35	4.35	56 949	40	83.5	50.9	73
N	0.71	2.78	4.35	1.74	37 575	33	71.2	0	0
O	0	1.23	4.35	1.74	12 380	40	83.5	50	56.7
Queensland					4 332 739	36.6	73.7		

[A]SA3 region identification is shown in Fig. 1 and can be obtained from the corresponding author.
[B]Proportion of Aboriginal and Torres Strait Islander peoples ranged from 1.0% to 5%.
[C]Proportion of SA1s with Index of Relative Socioeconomic Advantage and Disadvantage (IRSAD) or Index of Education and Occupation (IEO) Deciles 1–3 (relatively greater disadvantage or lower education and occupation status) for each SA3 region.
[D]SA3 region located within West Moreton Hospital and Health Services district.

The geographic source of liver clinic out-patients differed between the different liver diseases (Fig. 1; Table 2. The identity of SA3 regions labelled A-X can be obtained from the corresponding author). For HBV, two SA3 regions accounted for one-quarter of the affected clinic population, with 12.4% and 13.4% of HBV patients each. Seven SA3 regions accounted for more than 60% of HBV patients, and the remaining regions had less than 5% HBV patients in each. In contrast, HCV was more widespread, with 11 SA3 regions accounting for 61% of patients (3.7–7.7% patients per region). NAFLD was somewhat localised, with 20% of the affected patients living in two SA3 regions (with 11.3% and 8.7% of patients), and nine regions accounting for 60% of patients (4.4–11.3% patients per region). The total number of ALD patients was relatively small, and their geographic location was diverse, with 10 SA3 regions accounting for 60% of patients (4.4–8.7% patients per region). Considering the geographic distribution of SA3 regions accommodating high proportions of hepatology out-patients, HBV

Table 3. Summary of generalised linear models examining potential associations between aggregate Statistical Area Level 2 (SA2) population characteristics and total demand (all aetiologies), non-alcoholic fatty liver disease (NAFLD), hepatitis C virus (HCV), hepatitis B virus (HBV) and alcohol-related liver disease (ALD)

CI, confidence interval; IRSAD, Index of Relative Socioeconomic Advantage and Disadvantage; IEO, Index of Education and Occupation; ME, Middle East; SE, south-east; NE, north-east; NW, north-west; ATSI, Aboriginal and Torres Strait Islander

Dependent variable, and model detail	Independent variables	Coefficient ($\times 10^3$)	95% CI	*P*-value
Total demand:	Median age	33.98	8.10, 59.86	0.01
SA2s $n = 102$;	Males	0.228	0.144, 0.312	<0.001
Model residual d.f. = 90;	IRSAD	–4.136	–5.854, –2.419	<0.001
Wald $\chi^2_{11} = 851.2$;	People born in:			
$P < 0.001$	Oceania	0.115	–0.274, 0.503	0.56
	North Africa and ME	3.018	1.339, 4.696	<0.001
	SE Asia	–0.166	–0.437, 0.105	0.23
	NE Asia	–0.166	–0.341, 0.009	0.06
	Southern and Central Asia	0.990	0.228, 1.752	0.01
	Americas	–0.347	–2.539, 1.845	0.76
	Sub-Saharan Africa	–1.808	–3.210, –0.407	0.01
	English not primary language spoken	887.5	–977.5, 2752.5	0.35
NAFLD:	Median age	48.55	–15.32, 112.41	0.14
SA2s $n = 102$;	IEO	–5.961	–8.543, –3.380	<0.001
Model residual d.f. = 93;	ATSI	0.979	–0.327, 2.284	0.14
Wald $\chi^2_8 = 178.1$;	People born in:			
$P < 0.001$	Australia	0.096	0.022, 0.169	0.01
	Oceania	–0.090	–0.699, 0.518	0.77
	North Africa and ME	5.304	2.672, 7.937	0.001
	SE Asia	–0.056	–0.239, 0.127	0.55
	NE Asia	–0.042	–0.274, 0.190	0.73
HCV:	Males	0.086	–0.017, 0.188	0.10
SA2s $n = 102$;	IRSAD	–5.986	–7.381, –4.590	<0.001
Residual d.f. = 95;	People born in:			
Wald $\chi^2_8 = 164.4$;	SE Europe	1.858	0.592, 3.124	<0.001
$P < 0.001$	North Africa and ME	0.527	–1.622, 2.677	0.63
	SE Asia	–0.157	–0.457, 0.143	0.31
	Americas	2.140	–1.851, 6.131	0.29
HBV:	IRSAD	–4.15	–6.50, –1.79	0.001
SA2s $n = 102$;	ATSI	1.147	0.010, 2.284	0.05
Residual d.f. = 92;	People born in:			
Wald $\chi^2_8 = 322.6$;	Oceania	0.504	0.003, 1.004	0.05
$P < 0.001$	NW Europe	0.618	0.069, 1.168	0.03
	SE Asia	0.126	–0.097, 0.348	0.27
	NE Asia	0.140	–0.078, 0.359	0.21
	Southern and Central Asia	0.948	–0.222, 2.117	0.11
ALD:	Median age	49.41	4.13, 94.70	0.03
SA2s $n = 102$;	IRSAD	–4.441	–6.819, –2.062	<0.001
Residual d.f. = 96;	People born in:			
Wald $\chi^2_8 = 59.1$;	Australia	0.090	0.015, 0.165	0.02
$P < 0.001$	North Africa and ME	3.457	0.623, 6.292	0.02
	SE Asia	0.051	–0.223, 0.325	0.72

Table 4. Generalised linear mixed (two-level, random intercept) models examining characteristics of individuals clustered in geographical areas associated with total demand (all aetiologies), non-alcoholic fatty liver disease (NAFLD), hepatitis C virus (HCV), hepatitis B virus (HBV) and alcohol-related liver disease (ALD)

ATSI, Australian Aboriginal or Torres Strait Islander; IRSAD, Index of Relative Social Advantage and Disadvantage; OR, odds ratio; CI, confidence interval; ME, Middle East; SE, south-east; NW, north-west; SC, southern and central; ICC, intraclass correlation coefficient

Dependent variable, and model detail	Independent variables	OR (95% CI)	*P*-value
All aetiologies:	Age	1.02 (0.99, 1.05)	0.23
$n = 1870$;	Gender	0.91 (0.83, 1.00)	0.06
Wald $\chi^2_{13} = 209\ 252$;	Country of birth		
$P < 0.001$; two-level model;	Australia: non-ATSI	Referent Group	
area ICC = 0.03 (95% CI 0.01, 0.10)	Australia: ATSI	24.47 (2.62, 228.88)	<0.01
	Oceania	1.86 (1.44, 2.39)	<0.001
	NW Europe	0.69 (0.53, 0.89)	<0.01
	SE Europe	2.13 (1.17, 3.86)	0.01
	North Africa and ME	2.23 (0.67, 7.43)	0.19
	SE Asia	4.32 (2.87, 6.49)	<0.001
	NW Asia	2.41 (1.32, 4.41)	0.01
	SC Asia	1.31 (0.57, 2.98)	0.53
	Americas[A]	–	–
	Sub-Saharan Africa	2.20 (1.35, 3.59)	<0.01
	Low English proficiency	1.61 (1.00, 2.60)	0.05
	IRSAD	0.99 (0.99, 0.99)	<0.001
NAFLD:	Age	1.00 (0.88, 1.14)	0.94
$n = 1037$;	Gender	0.69 (0.55, 0.86)	0.001
Wald $\chi^2_{12} = 40\ 694$;	Country of birth		
$P < 0.001$; two-level model;	Australia: non-ATSI	Referent Group	
area ICC = 0.47 (95% CI 0.17, 0.79)	Australia: ATSI	55.28 (6.39, 478.12)	<0.001
	Oceania	1.81 (0.90, 3.62)	0.10
	NW Europe	0.23 (0.03, 1.56)	0.13
	SE Europe	0.93 (0.24, 3.65)	0.92
	North Africa and ME	1.32 (0.23, 7.63)	0.76
	SE Asia	4.33 (2.30, 8.16)	<0.001
	NW Asia	3.93 (1.91, 8.08)	<0.001
	SC Asia[A]	–	–
	Sub-Saharan Africa	2.16 (0.91, 5.15)	0.08
	Low English proficiency	1.28 (0.84, 1.95)	0.26
	IRSAD	0.97 (0.96, 0.99)	<0.01
HCV:	Age	1.02 (0.99, 1.06)	0.13
$n = 1263$;	Gender	0.96 (0.79, 1.15)	0.64
Wald $\chi^2_{13} = 56\ 541$;	Country of birth		
$P < 0.001$; two-level model;	Australia: non-ATSI	Referent Group	
area ICC = 0.12 (95% CI 0.03, 0.38)	Australia: ATSI	27.26 (2.88, 258.41)	<0.01
	Oceania	1.68 (1.28, 2.21)	<0.001
	NW Europe	0.95 (0.61, 1.47)	0.81
	SE Europe	2.58 (1.35, 4.96)	<0.01
	North Africa and ME	3.04 (1.13, 8.15)	0.03
	SE Asia	3.39 (1.84, 6.23)	<0.001
	NW Asia	2.60 (1.01, 6.65)	0.05
	SC Asia	2.19 (0.64, 7.44)	0.21
	Sub-Saharan Africa	2.09 (1.33, 3.29)	0.001
	Low English proficiency	1.92 (0.91, 4.06)	0.09
	IRSAD	0.99 (0.98, 0.99)	<0.001
HBV:	Age	1.03 (0.99, 1.08)	0.18
$n = 1222$;	Gender	0.99 (0.88, 1.11)	0.86
Wald $\chi^2_{13} = 42\ 187$;	Country of birth		
$P < 0.001$; two-level model;	Australia: non-ATSI	Referent Group	
area ICC = 0.06 (95% CI 0.01, 0.23)	Australia: ATSI	29.55 (2.52, 347.10)	<0.01
	Oceania	1.74 (0.94, 3.24)	0.08
	NW Europe	0.55 (0.34, 0.90)	0.02

(*continued next page*)

Table 4. (*continued*)

Dependent variable, and model detail	Independent variables	OR (95% CI)	*P*-value
	SE Europe	2.21 (1.13, 4.31)	0.02
	North Africa and ME	2.10 (0.33, 13.23)	0.43
	SE Asia	5.34 (3.72, 7.67)	<0.001
	NW Asia	2.69 (1.36, 5.34)	<0.01
	SC Asia	0.79 (0.36, 1.70)	0.54
	Sub-Saharan Africa	3.31 (1.53, 7.16)	<0.01
	Low English proficiency	1.44 (0.78, 2.68)	0.25
	IRSAD	0.99 (0.98, 1.00)	<0.01
ALD:	Age	1.04 (0.95, 1.13)	0.39
$n = 1000$;	Gender	0.91 (0.54, 1.53)	0.71
Wald $\chi^2_{12} = 38.6$;	Country of birth		
$P < 0.001$; one-level model;	Australia: non-ATSI	Referent Group	
no significant region effect	Australia: ATSI	7.55 (0.73, 78.63)	0.09
	Oceania	3.82 (1.97, 7.39)	<0.001
	NW Europe	0.72 (0.26, 2.05)	0.54
	SE Europe	2.20 (0.46, 10.51)	0.32
	North Africa and ME[A]	–	–
	SE Asia	5.64 (2.09, 15.24)	0.001
	NW Asia	1.40 (0.14, 13.67)	0.77
	SC Asia	2.57 (0.56, 11.89)	0.23
	Sub-Saharan Africa	1.37 (0.23, 8.02)	0.73
	Low English proficiency	0.49 (0.11, 2.29)	0.37
	IRSAD	0.99 (0.98, 1.00)	0.05

[A]No people born in this region were present in the clinic sample for this aetiology model.

showed a clustered distribution (adjacent SA3s), whereas HCV, NAFLD and ALD showed a more even geographic distribution (Fig. 1).

Demographic characteristics of geographic areas with high liver disease prevalence

In order to describe the ethnic and socioeconomic characteristics of areas of need for hepatology services, we examined the ABS census data for the geographic areas with high demand. The proportion of residents from different culturally and linguistically diverse (CALD) backgrounds varied among SA3 regions. For example, the four SA3 regions accounting for 40% of clinic patients with HBV had the highest prevalence of people born in Vietnam, China and New Zealand. In SA3-A, 8.5% of people were born in Vietnam (cf. 0.4% in Queensland); 8.4% of people in SA3-B and 8.5% of people in SA3-C were born in New Zealand (cf. 4.4% in Queensland); and 9.6% of people in SA3-I were born in China (cf. 0.6% in Queensland). There was substantial overlap in the SA3 regions accounting for HBV and HCV, and therefore in the proportion of residents born in Vietnam, China and New Zealand.

For HBV, HCV and NAFLD, the two SA3 regions accounting for the highest proportion of patients had a higher representation of greater socioeconomic and occupational disadvantage (44% and 52% respectively of SA1s with IRSAD Deciles 1–3; 41.5% and 84.7% respectively of SA1s with IEO Deciles 1–3). In contrast, the two SA3 regions accounting for the highest proportion of patients with ALD had a relative lack of socioeconomic and occupational disadvantage (12% and 20% respectively of SA1s with IRSAD Deciles 1–3; 15.3% and 22.3% respectively of SA1s with IEO Deciles 1–3). However, overall there was a wide spectrum of socioeconomic and occupational advantage and disadvantage among areas of high demand (0–56.3% of SA1s with IRSAD Deciles 1–3 and 0–84.7% of SA1s with IEO Deciles 1–3).

Multivariable and multilevel analyses

Multivariable modelling was used to examine aggregate population-level characteristics associated with total and aetiology-specific demand for hepatology services arising from SA2s within the health service catchment (Table 3). In summary, aggregate population characteristics associated with higher demand for hepatology services included older median age, more males, greater socioeconomic disadvantage, more ATSI individuals (HBV only), more Australian-born individuals (NAFLD and ALD only) and individuals born in particular geographical regions (aetiology dependent).

Multilevel modelling was used to examine attributes of hepatology out-patients clustered within geographical regions (all patients and patients with HBV, HCV or NAFLD) compared with a representative sample of individuals from the same region matched to the clinic cohort (Table 4). There was greater correlation between individuals within the same regions for each of these models, although the ICC values indicated the degree of clustering was not consistent across each model. Because of a weaker geographical clustering effect for ALD patients, the two-level ALD models were not superior to a simpler one-level model (Table 4). In summary, individuals were more likely to have presented to the participating hepatology service than age- and gender-matched peers living in the same area if they were ATSI, were born in Oceania, Europe, South-east Asia, North-west Asia or Sub-Saharan Africa, reported low levels of English

Table 5. Sensitivity analysis of generalised linear mixed (two-level, random intercept) models examining characteristics of individuals clustered in geographical areas associated with total demand (all aetiologies), non-alcoholic fatty liver disease (NAFLD), hepatitis C virus (HCV), hepatitis B virus (HBV) and alcohol-related liver disease (ALD)

ATSI, Australian Aboriginal or Torres Strait Islander; IEO, Index of Educational and Occupation; CI, confidence interval; ME, Middle East; SE, south-east; NW, north-west; SC, southern and central; ICC, intraclass correlation coefficient

Model dependent variable	Independent variables	Coefficient (95% CI)	*P*-value
All aetiologies:	Age	1.02 (0.99, 1.05)	0.12
$n = 1870$;	Gender	0.90 (0.80, 1.02)	0.11
Wald $\chi^2_{13} = 90\ 590.88$;	Country of birth		
$P < 0.001$; two-level model;	Australia: non-ATSI	Referent Group	
area ICC = 0.12 (95% CI 0.05, 0.27)	Australia: ATSI	25.86 (2.82, 237.19)	<0.01
	Oceania	1.90 (1.45, 2.50)	<0.001
	NW Europe	0.69 (0.54, 0.88)	<0.01
	SE Europe	2.15 (1.15, 4.04)	0.02
	North Africa and ME	2.16 (0.64, 7.33)	0.22
	SE Asia	4.43 (2.79, 7.02)	<0.001
	NW Asia	2.16 (1.09, 4.30)	0.03
	SC Asia	1.35 (0.60, 3.01)	0.47
	Americas[A]	–	–
	Sub-Saharan Africa	2.43 (1.48, 3.99)	<0.001
	Low English proficiency	1.72 (1.03, 2.86)	0.04
	IEO	0.99 (0.98, 0.99)	<0.001
NAFLD:	Age	1.01 (0.88, 1.15)	0.92
$n = 1037$;	Gender	0.82 (0.64, 1.05)	0.12
$\chi^2_{12} = 97\ 503$;	Country of birth		
$P < 0.001$; two-level model;	Australia: non-ATSI	Referent Group	
area ICC = 0.89 (95% CI 0.70, 0.97)	Australia: ATSI	157.38 (18.72, 1322.84)	<0.001
	Oceania	1.99 (1.06, 3.76)	0.03
	NW Europe	0.24 (0.04, 1.34)	0.11
	SE Europe	1.19 (0.30, 4.78)	0.80
	North Africa and ME	0.79 (0.23, 2.69)	0.70
	SE Asia	4.74 (2.10, 10.67)	<0.001
	NW Asia	3.43 (1.46, 8.05)	<0.01
	SC Asia[A]	–	–
	Sub-Saharan Africa	2.39 (1.09, 5.28)	0.03
	Low English proficiency	1.33 (0.79, 2.22)	0.28
	IEO	0.94 (0.93, 0.96)	<0.001
HCV:	Age	1.03 (0.99, 1.06)	0.11
$n = 1263$;	Gender	0.93 (0.75, 1.15)	0.50
$\chi^2_{13} = 117\ 030.01$;	Country of birth		
$P < 0.001$; two-level model;	Australia: non-ATSI	Referent Group	
area ICC = 0.36 (95% CI 0.13, 0.66)	Australia: ATSI	37.14 (5.80, 237.85)	<0.001
	Oceania	1.68 (1.28, 2.20)	<0.001
	NW Europe	0.92 (0.59, 1.42)	0.69
	SE Europe	2.64 (1.21, 5.73)	0.01
	North Africa and ME	2.71 (0.98, 7.48)	0.06
	SE Asia	3.32 (1.64, 6.73)	0.001
	NW Asia	2.17 (0.78, 6.07)	0.14
	SC Asia	2.20 (0.69, 7.02)	0.18
	Sub-Saharan Africa	2.19 (1.42, 3.38)	<0.001
	Low English proficiency	2.11 (0.91, 4.87)	0.08
	IEO	0.98 (0.96, 1.00)	0.06
HBV:	Age	1.04 (0.99, 1.08)	0.10
$n = 1222$;	Gender	0.98 (0.87, 1.10)	0.70
Wald $\chi^2_{13} = 34\ 804$;	Country of birth		
$P < 0.001$; two-level model;	Australia: non-ATSI	Referent Group	
area ICC = 0.22 (95% CI 0.08, 0.49)	Australia: ATSI	32.16 (2.77, 373.96)	<0.01
	Oceania	1.73 (0.93, 3.21)	0.09
	NW Europe	0.54 (0.33, 0.88)	0.01
	SE Europe	2.09 (1.07, 4.08)	0.03

(*continued next page*)

Table 5. (*continued*)

Model dependent variable	Independent variables	Coefficient (95% CI)	*P*-value
	North Africa and ME	1.97 (0.34, 11.24)	0.45
	SE Asia	5.71 (3.99, 8.16)	<0.001
	NW Asia	2.51 (1.42, 4.45)	<0.01
	SC Asia	0.76 (0.34, 1.72)	0.51
	Sub-Saharan Africa	3.52 (1.64, 7.56)	0.001
	Low English proficiency	1.50 (0.83, 2.71)	0.18
	IEO	0.98 (0.97, 1.00)	0.03
ALD:	Age	1.03 (0.95, 1.12)	0.49
$n = 1000$;	Gender	0.90 (0.53, 1.53)	0.70
Wald $\chi^2_{12} = 37.5$;	Country of birth		
$P < 0.001$; one-level model;	Australia: non-ATSI	Referent Group	
no significant area effect	Australia: ATSI	14.19 (1.17, 171.62)	0.04
	Oceania	3.66 (1.89, 7.09)	<0.001
	NW Europe	0.72 (0.25, 2.05)	0.54
	SE Europe	2.08 (0.44, 9.88)	0.36
	North Africa and ME[A]	–	–
	SE Asia	5.51 (2.05, 14.83)	<0.001
	NW Asia	1.25 (0.13, 12.27)	0.85
	SC Asia	2.41 (0.52, 11.06)	0.26
	Sub-Saharan Africa	1.47 (0.21, 10.46)	0.70
	Low English proficiency	0.57 (0.12, 2.72)	0.48
	IEO	1.00 (0.99, 1.00)	0.10

[A]No people born in this region were present in the clinic sample for this aetiology model.

proficiency or lived in a neighbourhood with greater socioeconomic disadvantage. The sensitivity analyses where the IEO was included in the models (rather than the collinear IRSAD) produced comparable results to the primary analysis (Table 5), with individuals living in areas with lower education and occupational status being more likely to have presented to the hospital hepatology service.

Discussion

The present study demonstrates the extensive geographic area (71 SA3 regions) from which people living with CLD travel to access a tertiary hospital liver clinic situated within the Metro South HHS district. It was interesting to note that one of the SA3 regions from which patients most frequently originated was in a neighbouring HHS district. Within the hospital catchment, a substantial proportion of people accessing hepatology services was clustered within specific geographic areas. Almost half the patient cohort resided in eight of the 21 SA3 areas within the HHS district. It is likely that outreach programs to engage and enhance primary care services in geographic areas from which the greatest demand for tertiary liver disease speciality care arises would yield greater relative return on investment than non-targeted programs.

The most striking geographic clustering was seen for people living with chronic HBV (Fig. 1*a*) in regions with a relatively high proportion of people born overseas, who may have been infected in their country of origin.[18] Australia implemented a strategy to prevent new HBV infection through universal infant vaccination in 2000.[19] As a result, chronic HBV infection has become a disease that disproportionately affects immigrants from countries of high prevalence (East Asia, Pacific nations, Sub-Saharan Africa), in addition to Australia's Indigenous communities (where vaccine coverage may not be optimal). The region of birth findings from the multilevel modelling (Table 4, HBV model) lend weight to this observation. Similar geographic clustering was seen for people living with chronic HCV. It is plausible that the regions with relatively high uptake of health care for HBV and HCV may also have the highest number of people currently not receiving appropriate care for viral hepatitis.[20] Among migrants, awareness of chronic HBV and HCV is low.[21] This is most likely attributable to a combination of poor health literacy, lack of symptoms during the early stages of liver disease and attention to health being perceived as less important than a range of settlement priorities. In addition to ethnicity, the data show an apparent ecological association between demand for hepatology services and both socioeconomic and education and occupation disadvantage. Low education status may have an effect on health education and outcomes.[22]

In order to increase awareness and appropriate management of viral hepatitis, public health strategists emphasise the importance of effective collaboration between the affected community, the healthcare sector providing services and the government funding the activities.[23] Successful outreach programs require acceptance from the affected community and different approaches (linguistic, cultural and social) may be needed for people with different ethnic backgrounds. GPs are at the core of primary health care provision in community settings, and many doctors may communicate with their patients in at least one language other than English.[24] However many GPs report that they have significant knowledge gaps about HBV,[24] HCV[25] and liver disease more broadly,[26] which may affect their capacity to effectively manage these conditions. Initiatives to educate and empower primary care providers working with communities most at risk of viral hepatitis and liver disease are an important

step in developing and maintaining effective and sustainable health services for people with liver disease.[27]

The present study has several strengths and limitations. First, area-based census information was used to infer socio-demographic characteristics. Therefore, there may be some discordance between individual socioeconomic status and area-level estimates. Second, the study included a relatively small number of patients with NAFLD and ALD, which provides limited capacity to investigate differences between disease aetiologies. However, the study does demonstrate the usefulness of a pragmatic approach to identifying geographic clusters from which service demand arises using routinely recorded information, providing a useful starting point for examining options to tailor health service interventions to address need for liver disease-specific health service resourcing. It may be considered a methodological strength that the study included consecutive patients and routinely recorded clinical information, as well as microdata supplied by the ABS in the form of a confidentialised unit record file. This enhanced the likelihood of both the clinic and non-clinic samples being representative of the populations from which they were drawn, while also being able to use person-level data in the multilevel modelling. Another strength of the study was the robust approach taken to disease classification, with aetiology and disease severity classified by a hepatologist.

Identifying where demand for hepatology clinical services arises is an important step for service planning and preparing for potential outreach programs to optimise community-based care. Development, enhancement, implementation and evaluation of interventions and outreach programs that can improve the quality, effectiveness and efficiency of health services for people with liver disease remains a priority for research in this field.

Conflict of interest

The authors declare that they have no competing interests.

Acknowledgements

This study was funded by the National Health and Medical Research Council (NHMRC) of Australia, the Queensland Government's Smart State Health and Medical Research Fund, the Princess Alexandra Hospital Research and Development Foundation and the Australian Liver Foundation. PCV, MJ and SMM are supported by NHMRC Career Development Fellowships (1083090, 1045247 and 1090440 respectively). EEP is supported by an NHMRC Practitioner Fellowship (1004242).

References

1 Wang FS, Fan JG, Zhang Z, Gao B, Wang HY. The global burden of liver disease: the major impact of China. *Hepatology* 2014; 60: 2099–108. doi:10.1002/hep.27406

2 Rehm J, Samokhvalov AV, Shield KD. Global burden of alcoholic liver diseases. *J Hepatol* 2013; 59: 160–8. doi:10.1016/j.jhep.2013.03.007

3 Yopp AC, Choti MA. Non-alcoholic steatohepatitis-related hepatocellular carcinoma: a growing epidemic? *Dig Dis* 2015; 33: 642–7. doi:10.1159/000438473

4 Williams R, Aspinall R, Bellis M, Camps-Walsh G, Cramp M, Dhawan A, Ferguson J, Forton D, Foster G, Gilmore I, Hickman M, Hudson M, Kelly D, Langford A, Lombard M, Longworth L, Martin N, Moriarty K, Newsome P. Addressing liver disease in the UK: a blueprint for attaining excellence in health care and reducing premature mortality from lifestyle issues of excess consumption of alcohol, obesity, and viral hepatitis. *Lancet* 2014; 384: 1953–97. doi:10.1016/S0140-6736(14)61838-9

5 El-Atem N, Wojcik K, Horsfall L, Irvine K, Johnson T, McPhail S, Powell E. Patterns of service utilisation within hepatology clinics: high prevalence of advanced liver disease *Internal Med J* 2016; 46: 420–6. doi:10.1111/imj.13008

6 Horsfall L, Macdonald G, Scott I, Skoien R, Khatun M, Moss C, Seligman C, Kardash C, Poxon V, Powell EE. Use of standardised assessment forms in referrals to hepatology outpatient services: implications for accurate triaging of patients with chronic hepatitis C. *Aust Health Rev* 2013; 37: 218–22. doi:10.1071/AH12162

7 Hepatitis Queensland. Liver clinics and treatment. Available at: http://www.hepqld.asn.au/directory [verified 12 July 2016].

8 StataCorp. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP; 2013.

9 Friedman J, Hastie T, Tibshirani R. Glmnet: lasso and elastic-net regularized generalized linear models. R package version 1. Available at: https://cran.r-project.org/web/packages/glmnet/index.html; 2009.

10 Australian Bureau of Statistics (ABS). Census of population and housing: expanded community profile Statistical Area 2 datapacks. Canberra: ABS; Available at: http://www.abs.gov.au/ausstats/abs@.nsf/productsbyCatalogue/974A1A5E73830E9ACA2570D90018BFB0?OpenDocument; 2011.

11 Australian Bureau of Statistics. Census of population and housing: basic community profile Statistical Area 2 datapacks. Canberra: ABS; Available at: http://www.abs.gov.au/ausstats/abs@.nsf/productsbyCatalogue/B7AD1DB8CB27192ECA2570D90018BFB2?OpenDocument; 2011.

12 Tibshirani R. Regression shrinkage and selection via the lasso. *J R Stat Soc, B* 1996; 58: 267–88.

13 Bozdogan H. Model selection and Akaike's information criterion (AIC): the general theory and its analytical extensions. *Psychometrika* 1987; 52: 345–70. doi:10.1007/BF02294361

14 Schwarz G. Estimating the dimension of a model. *Ann Stat* 1978; 6: 461–4. doi:10.1214/aos/1176344136

15 Huber PJ. The behavior of maximum likelihood estimates under non-standard conditions. In: Le Cam, L, Newyman, J., editors. Proceedings of the fifth Berkeley symposium on mathematical statistics and probability. Berkley: University of California Press; 1967. pp. 221–33.

16 White H. A heteroskedasticity–consistent covariance matrix estimator and a direct test for heteroskedasticity. *Econometrica* 1980; 48: 817–38. doi:10.2307/1912934

17 Australian Bureau of Statistics (ABS). Custom confidentialised unit record file – master, microdata: census of population and housing sample file 2011 basic. ABS, Canberra; supplied on CD-ROM. 2011.

18 Schweitzer A, Horn J, Mikolajczyk RT, Krause G, Ott JJ. Estimations of worldwide prevalence of chronic hepatitis B virus infection: a systematic review of data published between 1965 and 2013. *Lancet* 2015; 386: 1546–55. doi:10.1016/S0140-6736(15)61412-X

19 Commonwealth of Australia Department of Health. Second national hepatitis B strategy 2014–2017. Canberra: Commonwealth of Australia; 2014.

20 Australasian Society for HIV Medicine. B. Hepatitis B mapping project: estimates of chronic hepatitis B diagnosis, monitoring and treatment by Medicare Local, 2012/13 – national report. Darlinghurst: Australasian Society for HIV Medicine; 2015.

21 Strong C, Hur K, Kim F, Pan J, Tran S, Juon HS. Sociodemographic characteristics, knowledge and prevalence of viral hepatitis infection among Vietnamese Americans at community screenings. *J Immigr Minor Health* 2015; 17: 298–301. doi:10.1007/s10903-014-0015-x

22 Ding D, Do A, Schmidt HM, Bauman AE. A widening gap? Changes in multiple lifestyle risk behaviours by socioeconomic status in New South Wales, Australia, 2002–2012. *PLoS One* 2015; 10: e0135338. doi:10.1371/journal.pone.0135338

23 Locarnini S, Hatzakis A, Chen DS, Lok A. Strategies to control hepatitis B: public policy, epidemiology, vaccine and drugs. *J Hepatol* 2015; 62(Suppl.): S76–86. doi:10.1016/j.jhep.2015.01.018

24 24 Wallace J, Hajarizadeh B, Richmond J, McNally S. Investigating general practice and hepatitis B. Melbourne: La Trobe University; 2012.

25 Cox J, Graves L, Marks E, Tremblay C, Stephenson R, Lambert-Lanning A, Steben M. Knowledge, attitudes and behaviours associated with the provision of hepatitis C care by Canadian family physicians. *J Viral Hepat* 2011; 18: e332–40. doi:10.1111/j.1365-2893.2010.01426.x

26 Loguercio C, Tiso A, Cotticelli G, Blanco Cdel V, Arpino G, Laringe M, Napoli L, Piccinocchi G, Bonfrate L, Grattagliano I, Ubaldi E, Portincasa P. Management of chronic liver disease by general practitioners in southern Italy: unmet educational needs. *Dig Liver Dis* 2011; 43: 736–41. doi:10.1016/j.dld.2011.04.013

27 Arora S, Kalishman S, Thornton K, Dion D, Murata G, Deming P, Parish B, Brown J, Komaromy M, Colleran K, Bankhurst A, Katzman J, Harkins M, Curet L, Cosgrove E, Pak W. Expanding access to hepatitis C virus treatment – Extension for Community Healthcare Outcomes (ECHO) project: disruptive innovation in specialty care. *Hepatology* 2010; 52: 1124–33. doi:10.1002/hep.23802